UNITED STATES AIR FORCE MATERIALS TECHNOLOGY HIGHLIGHTS

Air Force Research Laboratory

Materials & Manufacturing Directorate

Wright-Patterson Air Force Base • Dayton, Ohio Fall 2005

ML Delivers Low-Cost Robot For Neutralizing Improvised Explosive Devices

Engineers from the Air Force Research Laboratory (AFRL) Materials and Manufacturing Directorate have rapidly prototyped, developed, and delivered low-cost expendable robots to disable and dispose of improvised explosive devices. The BomBot, which has already established its value during a variety of mission profiles in Haiti, Afghanistan and Iraq, was delivered to support requests from Air Combat Command (ACC), the Marines, and Central Air Forces (CENTAF).

ML engineers responded to an urgent need from the joint services explosive ordnance disposal (EOD) community for a low-cost, remotely controlled robot that can be rapidly deployed to place explosive charges on or near an improvised explosive device without exposing the system operator to danger. This compact and versatile system, which costs roughly $2,900, is being deployed in rigorous environmental conditions where more expensive robots with a greater logistical burden are currently used. In just 90 days, the first protoypes of the system were delivered to users in the field. This program demonstrates ML's commitment to rapid delivery of cutting-edge technology solutions, which exceed the capabilities of existing systems, to meet urgent and compelling warfighter needs.

IEDs, or improvised explosive devices, are key instruments of terror that conform to no set rules or standards; the construction is left entirely to the imagination and ingenuity of the evil-doer. The devices can be disguised to look like common everyday objects, and to make matters worse, the blueprints for these bombs are easily available.

When an IED is identified, rarely do EOD personnel attempt to dispose of these explosives by hand. Instead, they approach them remotely, sometimes dispatching robots costing $110,000 to $140,000 to disable or detonate the packages. Many of the current systems are large, must be transported on a HumVee or by trailer, and move at speeds of just a few miles an hour. In addition, these robots sometimes draw unwanted attention to an incident site, where keeping warfighters and civilians at a safe standoff distance is imperative.

The need for a low-cost, compact robot with a decreased logistical burden was quickly identified by the joint services EOD community participating in a notional concept working group. With IED use in areas of conflict overseas becoming commonplace and the Combating Terrorism Technology Support Office receiving official requests for new robotic tools and technologies from EOD personnel in the field, ML began development of the BomBot.

The BomBot is a modified 4x4 remote controlled truck that has been equipped with a pan and tilt camera and a charge dispenser. The robot can reach speeds of 30 to 35 miles an hour. However, a specially designed control unit, developed by Nomadio Inc., allows the operator to regulate the speed at low, medium and high settings. Nomadio has experience developing high redundancy, high security, short range digital radio systems that are intended for the command and control of military robots. Nomadio's technology provides the robots with secure, frequency hopping command and control, and the ability to relay information back from the

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The completed BomBot.

An EOD specialist tests the capabilities of the BomBot's control unit.

Vein Viewing Technology CRADA Helps Provide Commercial Product Release

Scientists from the Air Force Research Laboratory Materials and Manufacturing Directorate (ML) have invented, developed, patented and licensed a breakthrough medical technology, a Vein Viewing device that can be used to see beneath the skin and through body sections to show the vasculature, the network of blood veins in the body, in a broad range of lighting conditions.

Due to the technology's potential for a broad range of civilian medical uses, ML established a Cooperative Research and Development Agreement (CRADA) with InfraRed Imaging Systems (IRIS) Inc., of Columbus, Ohio, to manufacture and market the technology to the medical industry, and to expand the technology to solve other critical medical challenges. IRIS has gone on to further develop the technology and create a product, the IRIS Vascular Viewer, for commercial release.

Developing the vein viewer technology will provide both the Air Force and the medical community with the solution to the need for a reliable and accurate method of viewing a patient's veins, rapidly and accurately in conditions where the lighting is less than optimal, and even abysmal. On the battlefield, in hospitals, and at the scene of accidents, prompt IV administration has the potential to save countless lives.

Military medical personnel have often said that one of the most immediate concerns on the battlefield is the ability to properly insert an IV into an injured soldier immediately after the wound occurs. This same thing has been said by other emergency medical personnel, like EMTs, of victims of car accidents or acts of violence. The procedure is especially difficult at night or in environments of restricted light and on patients whose veins are not easily seen through the skin. The Air Force Research Laboratory's Materials and Manufacturing Directorate (ML) began addressing this concern in 1994.

Through the research done by ML scientists and engineers, Vein Viewer technology was developed. This technology uses night vision goggles that were equipped with special light filters, developed by the Air Force, that allowed the viewer to see infrared light passing through the patient's body, except in the areas that are blocked by blood moving through veins and arteries. As a result, the medical professionals were able to see veins and arteries quicker, in poor lighting conditions and on patients whose veins were not easily visible. Medical professionals having the ability to clearly and quickly see the veins, saves the patients from being poked with a needle multiple times. This is especially helpful for newborn babies that are very sensitive to pain and also have extremely tiny veins. Additional experiments also proved that the needle beneath the skin would also be visible.

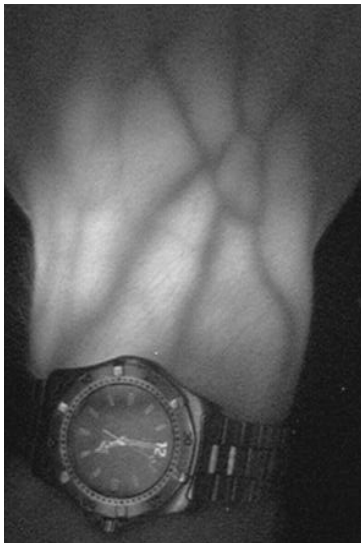
Because the Vein Viewer's technology encompassed such a broad range of civilian applications including emergency medical services, trauma centers, blood banks, pediatric and geriatric care facilities, and a variety of surgical procedures, ML scientists attempted to license the technology to large companies in the hopes that it would become available for civilian use.

In 2002, ML teamed with InfraRed Systems (IRIS) Inc., who had the skill to aid them in transition of the technology to the medical community. Under a Cooperative Research and Development Agreement (CRADA) with IRIS to expand and market the technology, ML scientists have put a great deal of time into aiding IRIS with the physics and physiology applicable to the invention, and serving as advisors about various technological issues associated with its usage.

IRIS continued its development of the Vein Viewer technology and in 2005, they introduced the first commercial product, the IRIS Vascular Viewer at the Infusion Nurses Society's (INS) annual meeting. The Vascular Viewer has four main components; an infrared light source, a light source controller, a viewing scope and a light source masking pad. It allows for the visualization of superficial veins, as well as deeply located veins. The visualization is non-invasive, direct and in real-time.

In addition to the exhibit at the INS annual meeting, two of the IRIS Vascular Viewers are going to be trialed at the Wilford Hall Medical Center at Lackland Air Force Base, Texas.

For more information, contact the Materials and Manufacturing Directorate's Technical Information and Support Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 05-226.



Photos of the vein viewing technique taken of the forearm and hand.

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robot's sensing devices. The system can be used in rigorous environmental conditions, several times daily, allowing EOD personnel to accomplish force protection and IED disposal activities from a safe standoff distance.

Based on feedback from EOD personnel who have received prototype BomBots, ML engineers made adjustments to the radio's capabilities, to stick control, and to the camera mount, and assisted in the development of an operating instruction for the technology. The entire program has been transitioned to Navy EOD Technology Division personnel at Indian Head Naval Ordnance Station, Md., who will work closely with West Virginia High Tech Consortium to initiate production on the final version of the BomBot.

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2005 Defense Manufacturing Conference Coming Soon

The 2005 Defense Manufacturing Conference (DMC '05) will be held 28 November -1 December 2005 at the Orlando World Center Marriott Resort and Convention Center, 8701 World Center Drive, Orlando, Florida, 32821.

DMC '05 will be sponsored by the Joint Defense Manufacturing Technology Panel (JDMTP) and hosted by the Office of Naval Research Manufacturing Technology Program. Based on the theme, "Manufacturing in the Changing DoD Environment", the agenda is structured to bring together leaders from government, industry and academia to exchange perspectives and information about the DoD Manufacturing Technology (ManTech) program, industrial base initiatives and related DoD transformation initiatives. The DMC has become the principal national forum for discussion of DoD industrial base policies, programs and capabilities, as well as counterpart industry initiatives. Critical issues include key technology development status, system/subsystem acquisition and sustainment affordability, diminishing supplier sources, assuring domestic technology transfer and the opportunity for greater use of commercial industrial processes and business practices for defense needs.

The conference general session will feature keynote speakers from the Department of Defense, Military Departments, Combatant Commands, Industry, Congress and several defense related associations. The conference technical program will cover the following topics; Metals Processing and Fabrication, Composites Processing and Fabrication, Electronics Processing and Fabrication, Lean Enterprise, Technology Transition, Energetics and Munitions, Defense Production Act Title III, Sustainment and Readiness, Supply Chain Advancement, Gee Whiz Technologies, Strategic Missile Defense, the emerging Small Business Innovative Research Program for Manufacturing, and a Poster Session.

For further information call the DMC '05 registration desk at: (937) 426-2808.

Fax: (937) 426-8755.
E-mail: meetings@utcdayton.com

Visit the DoD ManTech Website at
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Air Force-Industry Research Effort Improves Semiconductor Film Quality

Air Force Research Laboratory (AFRL) scientists, working with Gratings, Inc., Albuquerque, N.M., successfully demonstrated the feasibility of producing improved quality semiconductor films that can be used to support a diverse range of advanced military and commercial applications.

The research was completed under an Air Force Small Business Innovation Research (SBIR) contract, and focused on the hetero-epitaxial growth of gallium arsenide (GaAs) and germanium (Ge) on silicon (Si) surfaces. Supported by research scientists at the Materials and Manufacturing Directorate (ML), Gratings Inc., reduced defect density—misalignments and dislocations in the atomic layering—by a factor of 10,000, an accomplishment that could have tremendous impact on the performance of semiconductor devices for future war-fighting systems, and commercial products.

Hetero-epitaxial films are commonplace in the realm of electronic and photonic devices. However, the quest for *new* and *improved* devices is inevitably linked to continuing advancements in epitaxial techniques and a clearer understanding of the physics underlying epitaxial growth. Epitaxial techniques are the methods by which scientists match up the orientation of a deposited crystal with the orientation of the crystal making up the underlying substrate material—in this case, silicon. When the crystal orientations of two (or more) different materials (*hetero*-epitaxial) are not lined up properly, the result is defects (i.e., misalignment and dislocation of atoms); an accumulation of which is referred to as the "defect density." AFRL's goal has been to *reduce* defect density, and thereby *increase* semiconductor efficiency.

Hetero-epitaxial growth of SiGe, Ge, and GaAs semiconductor films on Si substrates has been a subject of ongoing commercial interest, due to a wide application base. Through patterning of silicon wafers, Gratings, Inc., was able to grow Ge on Si with a defect density of approximately 10^5 per centimeter squared (cm^{-2}), as measured by transmission electron microscopy (TEM) and other key factors. This magnitude of improvement could well represent the highest quality Ge hetero-epitaxial films on Si ever attained.

High-quality hetero-epitaxial growth on Si substrates beyond what is called critical

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thickness is difficult to achieve due to lattice constant and thermal expansion coefficient mismatch. One method of eliminating or reducing lattice and thermal mismatch is to form a "virtual" substrate through either a graded buffer layer or by limiting the lateral dimensions. Phase II of this SBIR program used both of these approaches to improve the material and device quality of hetero-epitaxial growth.

This effort has expanded the potential for extremely high quality semiconductor films. The work also resulted in the development of innovative techniques for Si quantum wire fabrication and silicon-on-insulator configurations. The technology developed under this SBIR program, conducted over a five-year period, has been awarded a patent.

The capabilities achieved in this research and development effort could lead to major improvements in semiconductor films used in optoelectronic integrated circuits, near-infrared photodetectors, and low-cost, low-weight high efficiency solar cells with high mechanical strength. Both the public and private sectors will benefit.

For more information, contact the Materials and Manufacturing Directorate's Technical Information and Support Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 05-152.

The USAF Materials Technology Highlights is published quarterly to provide information on materials research and development activities by Air Force Research Laboratory's Materials & Manufacturing Directorate. For more information on subjects covered in "Highlights" or to be added to the "Highlights" mailing list, contact the Materials & Manufacturing Directorate Technology Information and Support Center at (937) 255-6469 or e-mail at techinfo@afrl.af.mil. Approved for Public Release (AFRL/WS#05-1956).

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